Abstract

A digital modulation technique that utilizes a spreading matrix to linearly transform an input symbol sequence into a transmit symbol sequence using a two-dimensional transmission matrix. The transmit symbol sequence is filtered, modulated, and transmitted over a channel. At the receiver, a received symbol sequence is captured, demodulated, equalized if needed, and again transformed with a recovery matrix that is an inverse of the spreading matrix that was used at the transmitter. By using an inverse matrix instead of a more conventional transposed matrix, it is possible to construct a matrix from non-orthogonal basis functions. This allows much greater flexibility in determining the properties of a transmitted symbol sequence. If a non-square transmission matrix is used, the number of symbols in the transmit symbol sequence may exceed the number of symbols in the input symbol sequence, creating redundant symbols. The redundant symbols may be used to replace any of the transmit symbols that were damaged by transmission impairments. Alternately, the redundant transmit symbols may be used to reduce the effects of random noise in an output symbol sequence. The transmit symbol sequence may optionally be transformed a second time at the transmitter by an inverse fast Fourier transform (IFTT) prior to transmission, in a technique comparable to OFDM (orthogonal frequency division multiplexing). The second transform process converts time domain symbols into frequency domain symbols. If some of the frequency domain symbols fall into frequency-selective deep channel fades, which are frequently encountered in wireless channels, redundant transmit symbols can be used to insure error-free reception.